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BAYER LEVERKUSEN (GERMANY)
Department for Crop Protection

Studies on the Control of Mangold Fly

by W. Kolbe, Leverkusen

The mangold fly (*Pegomyia hyoscyami ssp. betae* Curtis) was first observed on beets by Curtis (1847). With the expansion of sugar beet and fodder beet farming, in progress since the end of the nineteenth century, the mangold fly has developed into a major pest occurring on an epidemic scale in many beet-growing countries of the world. The damage caused by the mangold fly is brought about chiefly by the mining larvae of the 1st. generation (in Spring) feeding on the leaf parenchyma. As a result, the growth of the beet plants is stunted especially when only a few leaves are present on the plants at the time of attack; severe infestation causes the plants to die. Since the resultant failures and poor growth can lead to appreciable decreases in yield, control practices are most essential.

Blomeyer (1891) reported on tests carried out by Werner at Bonn-Poppelsdorf, with the object of preventing the soft larvae from feeding by squeezing them in the leaves, and of decimating the following generations by plucking attacked leaves. Bremer and Kaufmann (1931) also referred to this possibility of control, but due to the large amount of work involved it did not become an important practice. Boeker (1908) suggested using sticky traps to catch the flies, and thus prevent them from laying eggs. According to Bremer and Kaufmann (1931), Rambousek recommended in 1921 in Czechoslowakia the practice of "keeping the beet fields under a heavy, suffocating cloud of smoke" to protect them against mangold fly attacks, and that "fires should be kept burning for at least two weeks" in the fields. An attempt was made by v. Veltheim (1926) to trap the flies in nets ("made of close-meshed wire gauze 6 metres long and 80 centimetres high, fitted at the sides with carrying grips"), also to prevent oviposition. As Bremer and Kaufmann (1931) described, "the nets were coated with fly glue, and then carried by two operators across the beet fields in such a manner that the bottom edge of the net just brushed the leaves. The object of this was to disturb the flies so that they would fly up from the plants and be caught on the glue". From the results of their studies, Bremer and Kaufmann (1931) arrived at the conclusion that by this method only a small percentage of the fly population colonizing the crop is killed. Moreover, as the spring generation of mangold flies does not remain constantly in the beet fields because of the slight protection afforded by the small beet plants, but only appears there to lay eggs, the sticky trap method had no prospects of success. According to Blunck (1925), Cameron attempted in England to prevent the flies from laying eggs by spraying the beet plants with a mixture of paraffin emulsion, nicotine and soft soap. Bremer and Kaufmann (1927) tested a method for killing the flies prior to oviposition by spraying poison bait. Sugar was used as the bait, and sodium arsenate, sodium fluoride or sodium fluosilicate was taken as the

insecticide; both ingredients were mixed in water and sprayed over the beet fields. Sodium arsenate proved harmful to plants even at very low concentrations. Blunck and Rademacher (1949) emphasized that it is a problem to control brooding mangold flies in Spring by applying sweetened poison baits because of the changeable habits of the pests, this evidently being the main reason why the control of the egg-laying flies themselves has not become an established practice.

The first chemical control of larvae was carried out by Wassiljew (1913) with barium chloride, and a good kill was obtained at concentrations of 6 to 7 %. In tests Bremer and Kaufmann (1931) conducted using barium chloride at the same concentrations (25 kilos per hectare), serious leaf scorching was observed. In addition to barium chloride, solutions of nicotine and nicotine sulphate were used to good effect against larvae by Rostrup in Denmark (1913) and Kemner in Sweden (1924). Bremer and Kaufmann (1931) obtained a poor kill of 1st. generation larvae in their trials with nicotine solutions. Consequently no satisfactory results were produced with either barium chloride or nicotine solutions, not to mention the unfavourable economic aspect of the practice.

As the mangold fly again occurred in considerable abundance in many countries after the second world war, the newly developed chlorinated hydrocarbons (DDT, HCH, toxaphene, chlordane, heptachlor, aldrin, dieldrin, endrin) and organophosphorus compounds (E 605®, CHLORTHION®, diazinon, DIPTEREX®) were tested in numerous experiments for their effect against mangold fly larvae. White (1947) reports on tests in England with DDT and HCH dusts, in which HCH gave good control. In trials conducted in Belgium, Ernould (1948) found that HCH wettable powder and HCH oil emulsion gave a 73 to 100 % kill of larvae within three days of the application; DDT oil emulsions produced a slower effect, and a 95 to 100 % kill was registered six days after the spray treatment. For DDT wettable powder, a 50 to 70 % kill of larvae was established three days after the application. Dosse and Rademacher (1948) carried out extensive tests in 1947 and 1948 with E 605, HCH and DDT in the Stuttgart area. E 605 applied in dust and liquid formulations gave a 100 % kill after 24 hours, and was fully effective against all larval stages even in bad weather; it should be mentioned that when egg-laying is prolonged a second spray is needed because the residual effect does not extend beyond a period of five days. The likewise tested DDT and HCH formulations did not give an adequate effect. DDT, HCH and E 605 were tested in laboratory and field trials which Dunning and Jones (1950) carried out in 1948/49 in England. E 605 gave fully effective control of larvae in these tests, and produced a much more rapid initial effect than DDT. For this latter a 100 % kill of larvae was not established until five days after the treatment in laboratory tests. Nolte and Klinkowski (1950) carried out field trials in the beet farming region of Central Germany with E 605 and other ester preparations, and found that the dust formulations of these products, by virtue of their better adhesion on the beet leaves, gave a greater effect than the liquid formulations. Jones and Dunning (1954) published a final report on field and laboratory tests carried on over several years (1948 to 1952) in England with DDT, HCH, aldrin, dieldrin, toxaphene and parathion; the chlorinated hydrocarbons were much alike in their effect, although parathion had a noticeably

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faster initial action and was the only product that gave an ovicidal effect. An 85 to 99 % kill was given by DDT within 6 days applied as an oil emulsion at high and low volumes of spray solution; the other formulations were less effective. When small bulks of water were used (and consequently higher concentrations), it was found that the tested oil emulsions caused leaf injuries.

In 1951 and 1953, Ticheler (1954) carried out field tests in Holland with parathion, HCH, DDT, toxaphene, aldrin and dieldrin. It was established that DDT oil emulsion acts more slowly than parathion oil emulsion whereas the effect of parathion lessens more rapidly. Since 1952, a series of tests have been carried out in France by Missonnier (1955a, 1955b, 1957) with parathion, methyl parathion, toxaphene, dieldrin, HCH, chlordane, DDT and demeton. Parathion, methyl parathion and dieldrin gave the best effect, and the emulsions were superior to the dust formulations. Berbéc (1955) also established in tests conducted in Poland (1950 to 1952) that a better effect is given by the emulsions, that is in respect of DDT and HCH, whereby the latter was the more effective of the two. Sweresomb-Subowski (1956) reports on trials with DDT and HCH carried out in Russia. Wilcox and Howland (1955) conducted in Southern California tests with parathion, mixtures of parathion, DDT and other preparations against larvae of the mangold fly; at the same time the effect of the products was tested against the pea leaf miner (*Liriomyza langei* Frick) which occurs on sugar beets in that region since 1950, together with the mangold fly. Dunning (1956) reports on the necessity in England in 1955 of having to control the black bean aphid (*Aphis fabae* Scop.) in addition to the mangold fly on beet crops; he states that when both pests occur simultaneously they can be controlled successfully with METASYSTOX® in a joint operation. Farmers in Cambridge were recommended by the National Agricultural Advisory Service (1957) to use DIPTEREX, a new and nontoxic insecticide (cf. Unterstenhöfer 1957a) to control the mangold fly, and to apply METASYSTOX against simultaneous occurrence of mangold fly and aphids.

Because of the severe infestation of mangold fly in 1956 and 1957, numerous trial controls were carried out in Germany especially with diazinon, DIPTEREX, endrin and parathion. Koltermann (1957, 1958) reports on tests in Lower Saxony with parathion, diazinon, DIPTEREX, endrin and other preparations; at the same time exact evaluations of yields were made in comparison with untreated checks. In view of the severe infestation, Bollow (1956), Lüdecke and Winner (1956), Heddergott (1957), Gersdorf (1956), Kersting (1957), Schlösser (1957) and Schrader (1957) published special instructions and advice for carrying out controls, in addition to the warnings issued by the crop protection authorities. It was also pointed out (anonymous, 1957) that since 1954 the mangold fly has been advancing in large numbers from the direction of Mecklenburg and Vorpommern, causing serious losses en route; according to Hering (1949) the carnation leaf miner (*Dizygomyza flavifrons* Mg.) is also said to be jointly responsible for the damage caused. In 1955 the border of the infestation zone in Lower Saxony was along a line between Soltau and Uelzen, whereas in 1956 the mangold fly had penetrated farther to cause severe damage over an area extending well into Rhineland. In 1957, severe infestation was also reported from South Germany. According to Rump and Niemöller (1958), the mangold fly first occurred as a major pest in Rheinland-Pfalz in 1957. Rogoll (1957) states that

from 1953 to 1956, according to records of the crop protection report service, mangold fly infestation increased steadily in Sachsen-Anhalt. In the districts of Magdeburg and Halle, only 269 hectares of beet fields were reported to be infested in May 1953, but by May 1956 the area infested had already increased to 52,628 hectares, and a severe outbreak in these districts was also forecast for 1957. Missonnier (1957) reports similar facts on the occurrence of

Fig. 1: The mangold fly usually lays several eggs at a time on the lower surface of the leaves. The larvae emerge after 4 to 6 days, immediately mine into the leaf beneath the egg, and feed on the leaf parenchyma

mangold fly in France. Whereas in 1954 the mangold fly caused appreciable damage only in coastal regions of Normandy and Northern France, one year later severe infestation was reported from parts well inside the country. By 1956, mangold fly infestation had spread to the Paris basin and the Ardennes, and it was anticipated that severe damage would be caused in 1957 north of a line running from Paris to Reims. The main injuries were inflicted by the first generation also in France.

Rump and Niemöller (1958) report that by intensively controlling the larvae of the spring generation, the following generations and the population of overwintering pupae can be reduced considerably as compared with colonization in untreated fields. A drop in the infestation rate of the following year can also be brought about by parasitization of pupae. Facts on the biology of the mangold fly are to be found in the papers published by Rump and Niemöller (1958) and Rogoll (1957), and also in the detailed studies of Blunck, Bremer and Kaufmann (1933).

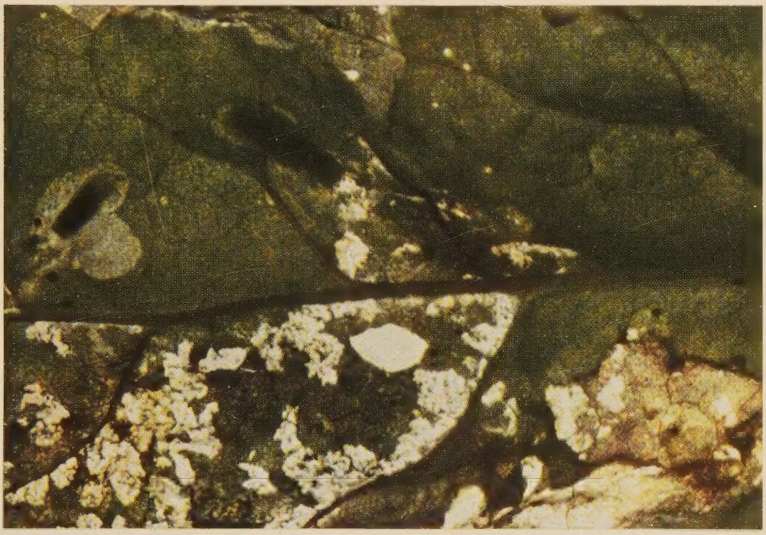


Fig. 2: The larva does not leave the inside of the leaf until it is ready to move to the ground for pupation. As the larval stage lasts 9 to 18 days depending upon the weather, each larva destroys by mining up to 10 square centimetres of leaf area when no controls are carried out

Another important point is forecast research — establishing whether a severe infestation of mangold fly is to be expected in the following Spring. These studies are based on the numbers of puape found in the sump beds of the sugar factories, and on test diggings made in the beet fields. In diggings carried out in Autumn 1956, Koltermann (1957) found on the average 250 pupae per square metre, in other words approximately 2½ million pupae per hectare, and forecast a "very severe infestation" of mangold fly for 1957 in the Göttingen area. In fact laying of up to 200 million eggs per hectare before the plants were thinned out exceeded all expectations in this area (Koltermann 1958). On the basis of results obtained in test diggings carried out in Autumn 1957, in which colonization of 25 to 600 pupae was registered per square metre in the Göttingen area, Koltermann (1958) reckons with the occurrence of mangold fly again in 1958 also in other districts. Judging from the number of pupae found in Rheinland-Pfalz, Rump and Niemöller (1958) forecast a severe occurrence of mangold fly also for 1958. According to

Rogoll (1957), studies conducted with the object of forecasting mangold fly infestation attach special importance in years of slight occurrence in order to be prepared in good time for a new calamity. It is evident that ever since the start of beet cultivation the control of mangold fly has always been considered as essential in view of the yield losses suffered as the result of severe infestation, a reason why the development of suitable insecticides for controlling this pest is so important.

Formulation of the problem

It is obvious from the details outlined in the preceding section that a product is needed for the control of mangold fly, which when applied kills within a short time larvae of all stages already mining in the leaf, in other words a product that has a rapid initial action, and which also features a good residual effect to check persistent egg laying and emergence of larvae. An initial action is understood to mean an effect giving very rapid control of emerged larvae of all stages, with the object of putting an end to any further feeding especially by older instars, so that the beet leaf will be damaged as little as possible. The residual effect is understood to mean the period over which a product is sufficiently effective, following a single spray, to keep the plants free of infestation despite emergence of new larvae during this time, or during which feeding by larvae is essentially checked due to the attainment of a high mortality rate (e. g. 70 %). It should be mentioned that the residual effect is influenced by the growth rate of the plants, which varies in the different stages of plant development and in changing weather conditions. Another factor of importance is a certain ovicidal effect of the product because by giving simultaneous kill of any unhatched eggs that are present, the overall effect is increased to no mean extent, and harm to the (assimilating) leaves is prevented. A special point is also that such a product has a low order of mammalian toxicity.

The partly conflicting views on the initial action and residual effect of products and active ingredients recommended on the German market for the control of mangold fly, and queries regarding efficacy in treatments with low volumes, especially for airplane applications, etc. were the prime reason for carrying out large-scale field tests from May 14 to June 15, 1957 in the Hanover—Hildesheim—Göttingen area. The already mentioned disproportionately heavy and prolonged egg-laying (April to June) in this region, the high rate of initial infestation in the 2 to 4 leaf stage (25 eggs per plant before thinning out), constant new egg-laying and a varying rate of new leaf growth (due to fluctuating temperatures) rendered it possible to determine the minimum residual effect of a spray or, alternatively, of the different preparations. On the other hand, the Hanover—Hildesheim—Göttingen area — evident from Table 1 — is one of the largest sugar beet farming zones in the Federal Republic of Germany, so that studies of control practices are also of economic interest.

Special interest was shown for the effect given by the newly developed insecticide DIPTEREX formulated as an emulsion, soluble powder and wettable powder, in comparison with endrin (Endrin "Bayer" liquid), E 605 and diazinon. The following questions had to be settled in these tests:

1. What initial action and residual effect are produced by the recommended preparations and active ingredients, respectively, namely diazinon,

Table 1: Beet acreages 1956*

	Sugar beet hectares	Sugar beet for seed production hectares	Fodder beet hectares	Fodder beet for seed production hectares
District of Hanover	16,539	580	13,644	659
District of Hildesheim	28,858	1,044	7,650	544
District of Lüneburg	26,289	221	12,238	137
District of Braunschweig	29,828	1,270	3,324	510
Lower Saxony	107,199	3,633	70,184	2,205
Federal Republic	269,005	5,978	472,937	5,234

* Federal Department of Statistics (1957)

DIPTEREX, endrin, E 605? Are there any differences in the effects given by the various DIPTEREX formulations, namely DIPTEREX emulsion, DIPTEREX soluble powder and DIPTEREX wettable powder?

2. Are there any differences in effect brought about by the varying bulks of water used (40 — 200 — 400 litres of water per hectare), and are there also differences for spray applications with ground equipment and aircraft?
3. Can a marked extension of the residual effect or acceleration of the initial effect be brought about by raising the dosages of preparations per hectare?
4. Apart from the larvicidal effect, do the preparations also give an ovicidal effect? If so, the spray effect would be increased as a result of this, and the leaf would be less harmed due to complete prevention of feeding.
5. When mangold flies and aphids occur simultaneously, what dosage of DIPTEREX must be added to the dosage of METASYSTOX (i) applied to control aphids, in order also to obtain an adequate initial and residual effect against mangold fly?

Test conditions and evaluation

All tests were carried out over relatively large areas (size of plots ranging from 0·1 to 3 hectares), and there were no replications for the individual tests. The test conditions (growth stage of beets, spray equipment, time of spraying, weather — heavy deluge of rain 30 minutes after carrying out a test) varied appreciably from test to test, introducing adequate deviation in the results. The following trials were carried out:

1. Spray application on May 14, 1957, Ruthe farm, district of Hildesheim, seed beets, Platz Patria I type ground sprayer, 300 litres of water per ha.

Weather: dry, sunny, 18 ° C, wind force 1

Products:		
	DIPTEREX Emulsion *) at	600 ccs/ha
	Endrin Emulsion at	400 ccs/ha
	DIPTEREX Soluble Powder **) at	300 g/ha
	E 605 conc. at	210 ccs/ha

2. Spray application on May 15, 1957, Calenberg farm, district of Springe, seed beets, helicopter, 40 litres of water per ha.

Weather: dry, sunny, 18—20 ° C, wind force 2—3

Products:		
	Endrin Emulsion at	400 ccs/ha
	DIPTEREX Emulsion at	600 ccs/ha
	DIPTEREX Soluble Powder at	300 g/ha

3. Spray application on May 17, 1957, Rössing farm, district of Springe, commercial beets, Danish type aircraft, 40 litres of water per ha.

Weather: dry, sunny, 18—20 ° C, wind force 3—4

Products:		
	DIPTEREX Emulsion at	450 ccs/ha
	DIPTEREX Emulsion at	700 ccs/ha
	DIPTEREX Soluble Powder at	300 g/ha
	DIPTEREX Soluble Powder at	200 g/ha

4. Spray application on May 17, 1957, Wittenberg farm, Mahlerten, district of Alfeld, seed beets, Danish type aircraft, 40 litres of water per ha.

Weather: dry, sunny, 18—20 ° C, wind force 2—3

Products:		
	DIPTEREX Emulsion at	600 ccs/ha
	DIPTEREX Soluble Powder at	300 g/ha
	DIPTEREX Soluble Powder at	200 g/ha

5. Spray application on May 17, 1957, Könnecke farm, Rössing, district of Springe, commercial beets, Rixe type horse-drawn sprayer, 360 litres of water per ha.

Weather: dry, sunny, 18—20 ° C, wind force 3

Products:		
	DIPTEREX Emulsion at	600 ccs/ha
	DIPTEREX Emulsion at	400 ccs/ha
	DIPTEREX Soluble Powder at	300 g/ha
	DIPTEREX Soluble Powder at	200 g/ha
	E 605 conc. at	210 ccs/ha
	Endrin Emulsion at	400 ccs/ha
	Endrin Emulsion at	400 ccs/ha

6. Spray application on May 24, 1957, Buchard farm, Altwarmbüchen, district of Burgdorf, commercial beets, Mauser type three-plunger high pressure sprayer, operating pressure of 10 atm. gauge, 200 litres of water per ha.

Weather: dry, cloudy, 15 ° C, wind force 2

Products:		
	DIPTEREX Emulsion at	600 ccs/ha
	DIPTEREX Emulsion at	900 ccs/ha
	DIPTEREX Soluble Powder at	400 g/ha
	DIPTEREX Soluble Powder at	600 g/ha
	Endrin Emulsion at	600 ccs/ha
	Endrin Emulsion at	400 ccs/ha
	Diazinon at	600 ccs/ha
	E 605 conc. at	300 ccs/ha

*) Active ingredient content of 50 %

**) DIPTEREX Soluble Powder introduced on the German market in 1958, as a 50 % product to be applied at a dosage of 600 gr./ha against mangold fly. The product tested in these trials was formulated to 80 %.

7. Spray application on June 3, 1957, Rössing farm, district of Springe, commercial beets, Rixe type horse-drawn sprayer, 240 litres of water per ha.

Weather: dry, sunny, 22—25 ° C, no wind

Products:

Diazinon at	600 ccs/ha
METASYSTOX (i) *)	400 ccs/ha
METASYSTOX (i) 300 ccs/ha + DIPTEREX Wettable Powder	300 g/ha
METASYSTOX (i) 200 ccs/ha + DIPTEREX Wettable Powder	200 g/ha
METASYSTOX (i) 300 ccs/ha + DIPTEREX Emulsion	300 ccs/ha
METASYSTOX (i) 300 ccs/ha + E 605 conc.	150 ccs/ha
DIPTEREX Wettable Powder *) at	600 g/ha
CHLORTHION conc. at	600 ccs/ha
Endrin Emulsion at	400 ccs/ha

8. Spray application on June 4, 1957, Drebing farm, Hedemünden, district of Hanover-Münden, commercial beets, Fricke type horse-drawn sprayer, 400 litres of water per ha.

Weather: cloudy, close, 22 ° C, wind force 1—2, heavy downpour of rain (18 mm)

Products:

METASYSTOX (i) 300 ccs/ha + DIPTEREX Wettable Powder	300 g/ha
METASYSTOX (i) 150 ccs/ha + DIPTEREX Wettable Powder	150 g/ha
DIPTEREX Wettable Powder 300 g/ha + Endrin Emulsion	200 ccs/ha
DIPTEREX Wettable Powder at	600 g/ha
Endrin Emulsion at	400 ccs/ha

9. Spray application on June 6, 1957, Wissemann farm, Bischhausen, district of Götttingen, commercial beets, Holder type horse-drawn sprayer, 400 litres of water per ha.

Weather very cloudy, 15 to 18 ° C

Products:

METASYSTOX (i) 300 ccs/ha + DIPTEREX Wettable Powder	300 g/ha
METASYSTOX (i) 200 ccs/ha + DIPTEREX Wettable Powder	200 g/ha
METASYSTOX (i) 150 ccs/ha + DIPTEREX Wettable Powder	150 g/ha
DIPTEREX Wettable Powder 300 g/ha + Endrin Emulsion	200 ccs/ha
DIPTEREX Wettable Powder at	600 g/ha
Endrin Emulsion at	400 ccs/ha
METASYSTOX (i) at	400 ccs/ha
Endrin Emulsion	200 ccs/ha + Diazinon 300 ccs/ha

Most of the tests included untreated checks. The initial infestation was established by sampling batches of 50 and 25 plants or leaves. The success of the treatment was evaluated on samples of 50, 35, 30 and 25 perceptibly mined leaves or plants, after periods of 1, 2, 4, 8, 12 or 1, 3, 5, 10 days. The larvae were dissected out of the leaves under a binocular lens, and a count taken of dead and living larvae; no allowance was made for the different larval stages. Mortality in the untreated checks was not given consideration in the evaluation of the results.

Results

The tests were carried out in crops of both sugar beet and beet grown for seed production. As the commercial beets and fodder beets were heavily colonized in 1957 already in the seed leaf stage, particularly the seedlings of the seed beet crops suffered severe infestation due to early oviposition. Schlösser

*) METASYSTOX (i) is marketed since 1958 in Germany as a 25 % product, and is applied to control aphids on beets at the same dosage of 800 ccs/ha as the previous METASYSTOX formulation. METASYSTOX (i) contains the effective P=O isomer of METASYSTOX, which in production could not previously be manufactured pure. In our trials, METASYSTOX (i) was tested as a 50 % preparation, a formulation that is sold in several other countries.

**) Active ingredient content of 50 %.

(1957) also stressed that whereas normally mangold flies lay their eggs chiefly on commercial beets, in 1957 seed beets were severely infested. It is evident from Tables 3 and 4 that seed beets were very heavily attacked also in our tests. On seed beets the average initial infestation was 50 eggs per leaf, and on commercial beets in the two to four leaf stage (without seed leaves) it was rated at 25 eggs per plant before the crops were thinned out. Lüdecke and Winner (1956) recommend that the best time for carrying out a control of mangold fly is when 6—8, 10—14 and 18—22 eggs per plant, respectively, are

Fig. 3: Due to the early severe infestation in May 1957, sprays had to be applied against mangold fly before the plants had formed many leaves. Aircraft as well as ground sprayers were used in the controls. Operation of aircraft is, however, hindered due to the parceling of fields or (as in the photo taken during plot spraying in our Test No. 3 at Rössing, Springe) by trees growing along the sides of roads and at the edges of fields

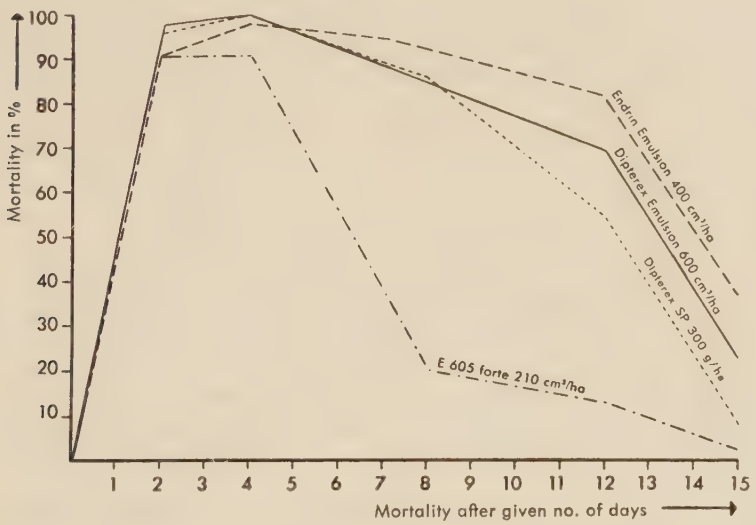
counted for 2, 3 and 4 pairs of leaves formed (without seed leaves). According to the National Agricultural Advisory Service (1957), marked economic damage is first caused by the mangold fly in Cambridge when more than 15 eggs are counted per plant in the three to four leaf stage, or more than 30 eggs per plant in the six to eight leaf stage. Jones and Dunning (1954) state that a control must be carried out when 30 eggs are counted per plant in the six to eight leaf stage. In our test area, the critical number of eggs per plant was thus well exceeded. Due to the high rate of infestation accompanied by persistent oviposition and rapid growth of foliage, it was possible to determine particularly the residual effect of the products. In the conditions prevailing in 1956, the residual effect had been overrated because the slighter and less persistent egg-laying of the 1st. generation did not take place until after the beets had completed their early stage of development.

Table 2 and Graph 1

Test No. 5 (Rössing, Springe*). Residual effect for applications with ground sprayers (360 litres of spray wash per hectare) in crops of commercial beets

Product	Dosage/ha	Percentage mortality after 48 hrs.		4 dys.		8 dys.		12 dys.		15 dys.	
		n¹)	%	n²)	%	n²)	%	n²)	%	n³)	%
DIPTEREX Emulsion	600 ccs	63	98	61	100	240	85	223	70	192	23
DIPTEREX Emulsion	400 ccs	41	98	62	100	210	84	231	58	157	11
DIPTEREX Soluble Powder	300 g	50	96	58	100	156	86	182	55	174	9
DIPTEREX Soluble Powder	200 g	46	91	63	98	234	55	301	54	148	7
E 605 conc.	210 ccs	42	91	59	91	275	21	237	13	124	2
Endrin Emulsion	400 ccs	67	90	59	98	274	96	244	82	106	37
Endrin Emulsion	400 ccs	50	92	49	98	209	93	304	88	155	35

n¹) = total no. of larvae (dead + harmed + living) in 25 sampled plants
n²) = in 50 leaves n³) = in 25 leaves %) = percentage of this number dead
Date of spraying: May 17, 1957 Checks: 19. 5., 21. 5., 25. 5., 29. 5., 1. 6.



Graph 1

*) To make for an easier comparison of the initial and residual effect of different preparations, several results of the different tests are plotted in graphs illustrated under the respective tables.

Residual effect with low and high rates of application, and in spray applications with aircraft and ground equipment

The results of Test No. 5 (Rössing, Springe) are given in Table 2 and Graph 1. The object of this trial was to test the effect of DIPTEREX emulsion and DIPTEREX soluble powder (at different concentrations) applied with ground sprayers using high rates of spray wash (360 litres per ha), in comparison with airplane applications using low quantities of spray wash (40 litres per ha). E 605 conc. and endrin emulsion were also included in this test. The severe initial infestation of 25 eggs per plant and the increasing number of larvae (n) found in the leaves in the consecutive checks, rendered it possible to express a definite opinion on the residual effect. Graph 1 in particular shows that the effect of DIPTEREX and endrin lessens appreciably after 12 to 14 days, and for E 605 conc. already after 5 or 6 days.

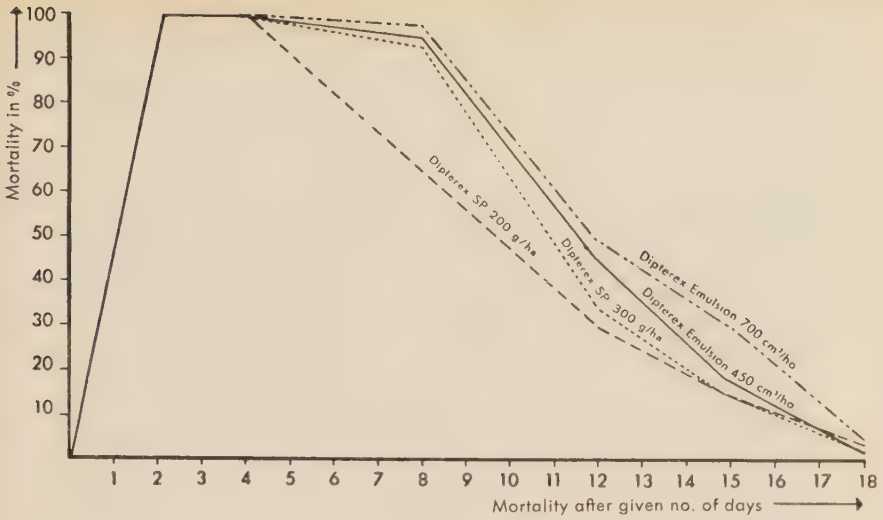
Information on the residual effect of DIPTEREX emulsion and DIPTEREX soluble powder applied by aircraft at a rate of only 40 litres of spray wash per hectare is provided by Test No. 3 (Rössing, Springe) on commercial beets and Test No. 4 (Mahlerten, Ahlfeld) on seed beets. As shown in Tables 3 and 4, or better still in the respective graphs, the initial and residual effects obtained in airplane applications are the same as for treatments carried out with ground sprayers (in Table 2 and Graph 1). The trial aerial applications were carried out with a Danish KZ III type aircraft of Agro-Kemi, Copenhagen, using a volume of 40 litres of spray wash per hectare applied with special type nozzles that gave a very fine and uniform spray mist. With regard to the actual operation of aircraft for this work, it should be mentioned that difficulty was experienced in flying down to the operating altitude over the plots due to trees growing along the sides of the roads and at the edges of the fields, a factor which particularly hinders the practical use of aircraft for controlling pests in agriculture because under certain circumstances edges of sprayed fields have to be given subsequent treatment with ground equipment.

Table 3 and Graph 2

Test No. 3 (Rössing, Springe). Residual effect given in aircraft treatment (40 litres of spray wash per hectare) of commercial beets

Product	Dosage/ha	Percentage mortality after									
		48 hrs.		4 dys.		8 dys.		12 dys.		15 dys.		18 dys.	
		n[1])	%	n[2])	%	n[2])	%	n[2])	%	n[3])	%	n[3])	%
DIPTEREX Emulsion	450 ccs	47	100	72	100	118	95	246	45	217	18	176	2
DIPTEREX Emulsion	700 ccs	48	100	66	100	116	98	294	49	179	40	159	5
DIPTEREX Soluble Powder	300 g	42	100	90	100	119	93	126	34	208	19	139	2
DIPTEREX Soluble Powder	200 g	35	100	73	100	169	65	120	30	149	16	193	4

n[1]) = no. of larvae in 25 sampled plants
n[2]) = in 50 leaves n[3]) = in 25 leaves % = percentage of this number dead
Date of spraying: May 17, 1957 Checks: 19. 5., 21. 5., 25. 5., 29. 5., 1. 6., 4. 6.



Graph 2

Table 4 and Graph 3 show the effect given by airplane spraying of seed beets. The plants were severely infested as indicated by the number (n) of larvae found in the leaf samples. The initial infestation amounted to 50 eggs per leaf. The evaluation revealed that due to the pronounced rosette growth of the seed plants (prior to the boot stage), it is very difficult to give all leaves full coverage. The lower half of the foliage is not properly wetted especially when small bulks of water are used. For example, investigation of a complaint about inadequate effect given by a product applied from aircraft in

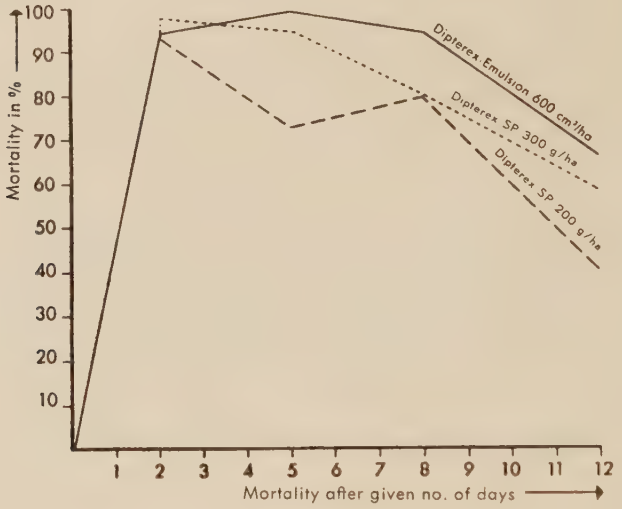
Table 4 and Graph 3

Test No. 4 (Mahlerten, Ahlfeld). Residual effect given in aircraft treatment (40 litres of spray wash per hectare) of seed beets

Product	Dosage/ha	Percentage mortality after 48 hrs. n¹)	%	5 dys. n¹)	%	8 dys. n¹)	%	12 dys. n¹)	%
DIPTEREX Emulsion	600 ccs	148	94	248	99	379	94	671	66
DIPTEREX Soluble Powder	300 g	119	98	250	95	554	80	733	58
DIPTEREX Soluble Powder	200 g	131	94	268	73	318	80	399	41

n¹) = no. of larvae in 25 sampled leaves
% = percentage of this number dead
Date of spraying: May 17, 1957
Checks: 19. 5., 22. 5., 25. 5., 29. 5.

crops of seed beets, revealed that on making a separate check of the percentage mortality of larvae in the top and bottom halves of the foliage, 84 % were dead in the top half and 44 % dead in the bottom half (several days after the spray application). As under certain circumstances the percentage mortality depends upon the position of the leaves within the rosette in crops of seed beets when low volumes of spray wash are applied, seed beets are, therefore, not particularly suitable for testing the residual effect of a product. It is shown in Table 4 that a 100 % kill was not obtained also in our Test No. 4 (Mahlerten, Alfeld) where seed beets were sprayed from aircraft at a rate of 40 litres of spray wash per hectare. Similar observations were made in Test No. 2 (Calenberg, Springe) where instead of the Danish airplane, use was made of a Swiss



Graph 3

helicopter to treat seed beets also at a rate of 40 litres of spray wash per hectare. In Test No. 1 (Ruthe, Hildesheim), a conventional type ground sprayer (Platz Patria I make) was used, and the spray wash applied at a rate of 300 litres per hectare. The efficacy attained with the higher volume was somewhat better but even here a complete kill was not given as in the crops of commercial beets.

In summarizing it may be said that in crops of commercial beets, the same initial and residual effect is produced at high and low volumes (with varying concentrations at constant dosages of preparation per hectare) as well as in aircraft applications and treatments with ground equipment. A somewhat more

Fig. 4: The helicopter has certain advantages over the aeroplane because it can take off and land vertically so that it does not require big runways. Consequently the spray tanks can be filled up often close to the fields requiring treatment, as in our photo taken during plot spraying of a seed beet crop in our Test No. 2 (Calenberg, Springe)

difficult proposition is generally encountered in crops of seed beets because the vigorous rosette growth makes it difficult to give all leaves full coverage irrespective of whether low or high volumes are used. But even in fields of seed beets, all methods of application give a high percentage kill of larvae.

Initial action and residual effect at high dosages

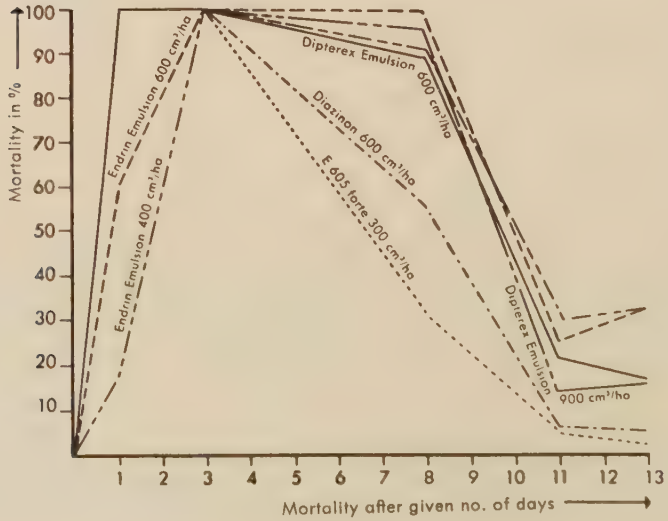
On May 24, 1957 a further test (No. 6) was conducted at Altwarmbüchen, Burgdorf, with the object of testing whether the residual effect can be extended and the initial effect accelerated by increasing the dosage of preparation applied per unit of area. Moreover as it became warmer at the end of May and in early June, it was possible to examine the residual effect during vigorous beet growth. The results in Table 5 and Graph 4 show that the application of considerably higher dosages — 900 ccs of DIPTEREX emulsion per ha, 600 g of DIPTEREX soluble powder per ha, and 600 ccs of endrin per ha — did not lead to an extension of the residual effect. Likewise, the recommended dosages are sufficient to give a fast initial effect. Endrin has a slow initial action at both higher and standard rates of application. Furthermore, the residual effect was shortened in comparison to Test No. 5 (Table 2), due to the warm, growth-stimulating weather prevailing during the Whitsun period, in fact to 9—10 days for DIPTEREX and endrin.

Table 5 and Graph 4

Test No. 6 (Altwarmbüchen, Burgdorf). Initial action and residual effect at higher dosages of preparation per hectare

Product	Dosage/ha	Percentage mortality after 24 hrs. n¹)	%	72 hrs. n²)	%	8 dys. n²)	%	11 dys. n¹)	%	13 dys. n¹)	%
DIPTEREX Emulsion	600 ccs	63	100	280	100	269¹)	89	146	22	130	17
DIPTEREX Emulsion	900 ccs	91	100	252	100	439	96	170	14	135	16
DIPTEREX Soluble Powder	400 g	92	100	305	100	394	96	179	10	123	14
DIPTEREX Soluble Powder	600 g	125	100	274	100	361	98	167	8	152	4
Endrin Emulsion	600 ccs	45	60	182	100	478	100	186	25	168	32
Endrin Emulsion	400 ccs	44	18	164	100	307¹)	91	136	30	150	32
Diazinon	600 ccs	56	100	190	100	487	55	173	6	272	5
E 605 conc.	300 ccs	63	100	179	100	416	31	186	5	254	2

n¹) = no. of larvae in 25 sampled leaves
n²) = in 50 leaves
% = percentage of this number dead
Date of spraying: May 24, 1957
Checks: 25. 5., 27. 5., 1. 6., 4. 6., 6. 6.



Graph 4

Effect of DIPTEREX in combined spraying with METASYSTOX (i) to give simultaneous control of mangold fly and aphids

Koltermann (1958) stresses that all insecticides applied to control mangold fly have the disadvantage of being ineffective against aphids at the recommended concentrations. When aphids occur together with mangold flies, special aphicides (METASYSTOX [i], METASYSTOX, SYSTOX®) must be added to the spray solutions, because these preparations are not sufficiently effective against mangold fly larvae. Even though the National Agricultural Advisory Service (1957) in Cambridge recommends METASYSTOX, as already mentioned, for joint controls of mangold fly and aphids, a good kill of mangold fly larvae is nevertheless not given. Therefore, the question was examined in several tests (Test No. 7, Rössing, Springe; Test No. 8, Hedemünden, Han.-Münden; Test No. 9, Bischhausen, Göttingen) to establish what dosage of DIPTEREX — when mangold flies and aphids occur at the same time — must be added to the dosage of METASYSTOX (i) applied against aphids in order to obtain a satisfactory initial action and residual effect against the mangold fly.

As shown in Tables 6, 7 and 8, METASYSTOX (i)*) and DIPTEREX were tested separately and combined at different dosages against mangold flies. The dosages of both products were varied. In these tests the 50 % DIPTEREX wettable powder formulation was used in contrast to the soluble powder formulation tested in the other trials. As the tests were not started until towards

Table 6 and Graph 5

Test No. 7 (Rössing, Springe). Effect given by combinations of METASYSTOX (i) + DIPTEREX

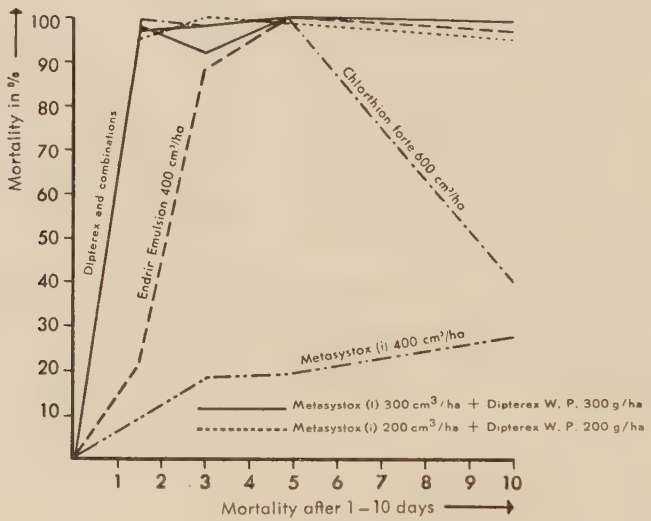
Product	Dosage/ha	Percentage mortality after 36 hrs.		72 hrs.		5 dys.		10 dys.	
		n¹)	%	n¹)	%	n¹)	%	n¹)	%
Diazinon	600 ccs	258	99	272	98	252	100	110	93
METASYSTOX (i)	400 ccs	160	10	177	18	170	19	41	27
METASYSTOX (i) + DIPTEREX Wettable Powder	300 ccs + 300 g	178	98	196	92	226	100	81	99
METASYSTOX (i) + DIPTEREX Wettable Powder	200 ccs + 200 g	167	96	186	100	171	99	106	95
METASYSTOX (i) + DIPTEREX Emulsion	300 ccs + 300 ccs	159	87	141	100	146	97	109	88
METASYSTOX (i) + E 605 conc.	300 ccs + 150 ccs	229	87	166	99	139	100	88	52
CHLORTHION conc.	600 g	177	97	163	98	200	100	112	99
DIPTEREX Wettable Powder	600 ccs	171	99	126	98	149	100	104	40
Endrin Emulsion	400 ccs	108	22	99	88	100	100	73	97

n¹) = no. of larvae in 25 sampled plants — % = percentage of this number dead
Date of spraying: June 3, 1957 — Checks: 4. 6., 6. 6., 8. 6., 13. 6.

*) Since the 50 % preparation was used here, and not the 25 % formulation marketed in Germany, the rates of application should be doubled accordingly.

the end of the flight and egg-laying period of the first mangold fly generation (June 3 to 5, 1957), it was not possible to make an exact study of the residual effect in view of the decreasing rate of infestation.

According to Table 6, METASYSTOX (i) gave only a weak effect against mangold fly in Test No. 7, but in Test No. 9 it was much more effective as



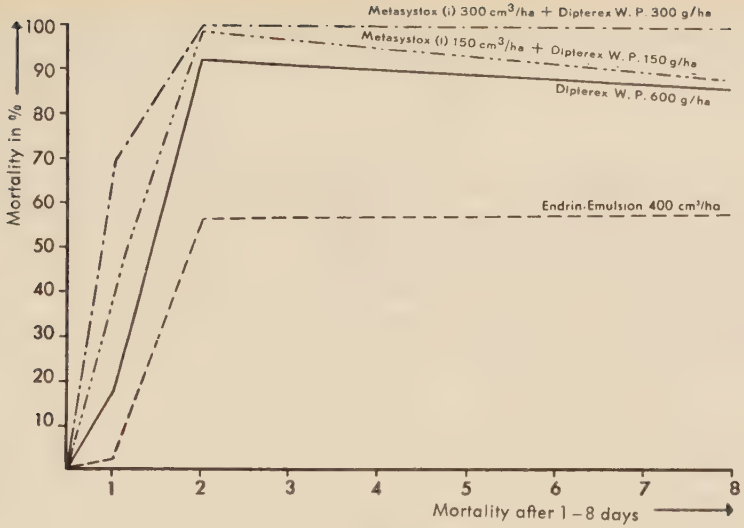
Graph 5

Table 7 and Graph 6:

Test No. 8 (Hedemünden, Hann.-Münden). Effect given by DIPTEREX and endrin when heavy rain (18 mm) fell 30 minutes after application.

Product	Dosage/ha		Percentage mortality after 24 hrs. n¹)	%	48 hrs. n²)	%	8 dys. n²)	%
METASYSTOX (i) DIPTEREX Wettable Powder	300 ccs 300 g	+	80	69	114	100	53	100
METASYSTOX (i) DIPTEREX Wettable Powder	150 ccs 150 g	+	87	39	140	99	82	89
DIPTEREX Wettable Powder Endrin Emulsion	300 g 200 ccs	+	94	82	133	99	65	99
DIPTEREX Wettable Powder Endrin Emulsion	600 g 400 ccs		127 117	18 2	113 108	92 56	85 57	86 58

n¹) = no. of larvae in 35 sampled leaves
n²) = in 30 leaves n³) = in 25 leaves
% = percentage of this number dead
Date of spraying: June 4, 1957
Checks: 5. 6., 6. 6., 12. 6.



Graph 6

shown in Table 8. In comparison with DIPTEREX and diazinon, the combinations gave a satisfactory kill of larvae in Test No. 7 even at a dosage of only 200 g of DIPTEREX wettable powder per hectare. CHLORTHION which in 1956 was used as a replacement for METASYSTOX to control aphids in the Hanover district, was also most effective against mangold fly in this test. Once again endrin had a slow initial action.

The object of Test No. 8 (Hedemünden, Hann.-Münden) was to test the combinations down to a DIPTEREX portion of 150 g/ha. It is evident from the results shown in Table 7 and Graph 6 that even at these low dosages, and also when the METASYSTOX (i) portion is reduced, a 100 % kill of larvae is given after 48 hours. The poor effect recorded after 24 hours, particularly for the test preparations (DIPTEREX, endrin) sprayed last, is to be attributed to a heavy downpour of rain that set in 30 minutes after the application had been carried out. Useful information is provided by the effect of DIPTEREX and endrin which were the last products to be sprayed before the rainfall. Table 7 shows that DIPTEREX did give a fairly high percentage kill of larvae after 48 hours despite the rain, while on the other hand the effect of endrin was weak.

Test No. 9 (Bischhausen, Göttingen) (Table 8) was carried out to test the combinations containing a DIPTEREX portion of 300, 200 and 150 g/ha, respectively. Here too, a dosage of 150 g of DIPTEREX wettable powder per hectare gave an adequate effect, although the residual effect could not be fully tested due to the lack of newly emerging larvae. Once again the initial action of endrin was slow.

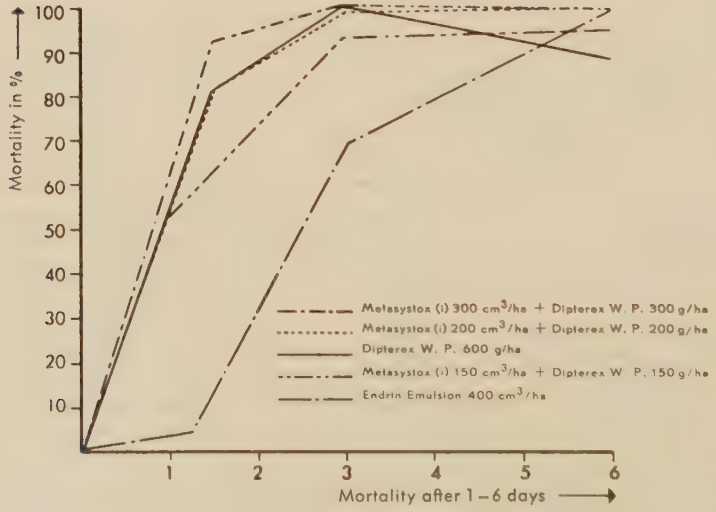
On the basis of these tests and results obtained in other studies, it can be asserted that when mangold flies and aphids occur simultaneously, a satisfactory kill of mangold fly larvae is given by adding 300 g of DIPTEREX

Table 8 and Graph 7:

Test No. 9 (Bischhausen, Göttingen). Effect given by combinations of METASYSTOX (i) + DIPTEREX combinations

Product	Dosage/ha	Percentage mortality after 36 hrs. n[1])	%	72 hrs. n[2])	%	6 dys. n[2])	%
METASYSTOX (i) + DIPTEREX Wettable Powder	300 ccs + 300 g	124	92	77	100	80	100
METASYSTOX (i) + DIPTEREX Wettable Powder	200 ccs + 200 g	150	80	133	99	94	100
METASYSTOX (i) + DIPTEREX Wettable Powder	150 ccs + 150 g	87	53	93	93	85	95
DIPTEREX Wettable Powder + Endrin Emulsion	300 g + 200 ccs	123	44	87	94	75	96
DIPTEREX Wettable Powder	600 g	113	81	149	100	124	88
Endrin Emulsion	400 ccs	194	5	165	68	66	99
METASYSTOX (i)	400 ccs	113	45	145	74	89	88
Endrin Emulsion + Diazinon	200 ccs + 300 ccs	194	38	269	66	110	96

n[1]) = no. of larvae in 30 sampled leaves
n[2]) = in 25 leaves
% = percentage of this number dead
Date of spraying: June 6, 1957
Checks: 7. 6., 8. 6., 12. 6.

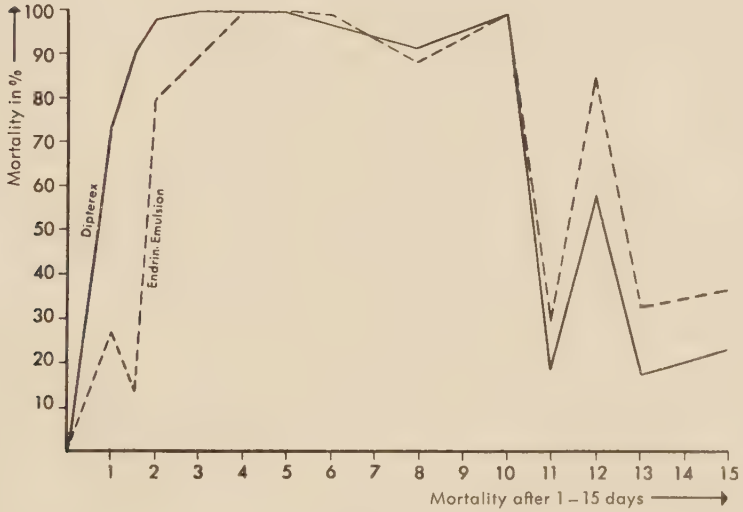


Graph 7

wettable powder*) or soluble powder*) per hectare or 300 ccs of DIPTEREX emulsion*) per hectare to METASYSTOX or METASYSTOX (i) applied at the standard rates.

Comparison of the effects given by endrin and DIPTEREX

Table 9 and Graph 8 provide a summarized survey of the effect given by DIPTEREX and endrin in the different tests. For DIPTEREX, consideration has been given only to the results obtained with the 50 % preparations (DIPTEREX emulsion, DIPTEREX wettable powder). Although a summary of this kind only has limited value — the different rates of application for DIPTEREX (400, 450, 600, 700 g and ccs, respectively, per hectare) and endrin (400, 600 ccs/ha) were included — the better initial action of DIPTEREX and the somewhat longer residual effect given by endrin under certain circumstances are nevertheless evident.



Graph 8

Ovicidal effect of the products

Bremer and Kaufmann (1931) point out on the basis of many years of research work carried out by them, that the eggs of the mangold fly "are by no means easily accessible to a direct control due to their position on the lower surface of the leaves, and moreover are essentially impermeable to aqueous liquids". Therefore certain difficulty is experienced in effectively checking feeding by larvae by killing them before emergence in the egg.

*) Active ingredient content of 50 %

Table 9 and Graph 8: Comparison of effects given by DIPTEREX and endrin (Average values for all tests)

Test No.	Percentage mortality after periods of												
	24 hrs.	36 hrs.	48 hrs.	72 hrs.	4 dys.	5 dys.	6 dys.	8 dys.	10 dys.	11 dys.	12 dys.	13 dys.	15 dys.
Endrin (30 values)													
5			90		98			96			82		37
5			92		98			93			88		35
6	60			100				100		25		32	
6	18			100				91		30		32	
7		22		88		100			97				
8	2		56					58					
9		5		68			99						
Average	27	14	79	89	98	100	99	88	97	28	85	32	36
DIPTEREX (44 values)													
5			98		100			85			70		23
5			98		100			84			58		11
3			100		100			95			45		18
3			100		100			98			49		40
4			94			99		94			66		
6	100			100				89		22		17	
6	100			100				96		14		16	
7		97		98		100			99				
8	18		92					86					
9		81		100				88					
Average	73	90	97	99·5	100	99·5		91	99	18	58	17	23

Jones and Dunning (1954) report that they also tested the ovicidal effect, in addition to the larvicidal action, of DDT, HCH, toxaphene, aldrin, dieldrin and parathion; they found that only parathion gave an ovicidal effect. Missonnier (1955b) investigated the effect of DDT, rotenon, HCH, white oil (summer oil) and parathion on the eggs of mangold fly. It is evident from Table 10 that a marked ovicidal effect was only given by parathion.

Table 10:
Ovicidal efficacy of different preparations against eggs of mangold fly (according to Missonnier 1955b)

Active ingredient	Formulation	Active ingredient content g/ha	Non-emerged eggs	Emerged eggs small mines (larvae dead)	Emerged eggs large mines (larvae living)
Untreated			8	6	86
DDT	Suspension	80	4	0	96
DDT	Emulsion	50	12	88	0
Rotenon	Emulsion	7·5	0	0	100
HCH (lindane)	Suspension	14·4	38	57	5
HCH	Suspension	140	23	67	10
HCH	Emulsion	100	14	86	0
White oil (summer oil)		800	48	42	10
Parathion	Emulsion	15	100	0	0

Missonnier (1955b) observed that parathion killed the larvae during embryonic development shortly before emergence*). According to Staudenmayer (1953) who examined the effect of E 605 on the respiration of silk moth eggs with the Warburg apparatus, a decrease in the breathing rate of the treated eggs, and consequently a toxic effect of E 605, is not established until 2 days before the emergence of the untreated checks. Staudenmayer (1955) was unable in further studies to establish a temporal relationship between the start of the toxic effect of E 605 and the development of the cholinesterase activity. The toxic effect of E 605 had already started (due to a decrease in the uptake of oxygen) before a cholinesterase activity of the eggs was perceptible. The toxic effect of organic phosphorus compounds on the embryos is therefore not only due to an inhibition of the cholinesterase. Potter et. al. (1957) arrived at the same results in studies they conducted to investigate relationships

*) The death of the fully developed larvae in the egg shortly before emergence is referred to in certain cases as an ovolarvicidal effect, whereas on the other hand this ovolarvicidal effect is also defined as being brought about when "the emerging larva is affected by poison when it is gnawing through the skin of the egg". In this paper, the ovicidal effect is understood to mean the mortality of the larva (or of the embryo) in the egg before emergence, and the larvicidal effect to mean the eradication of the larva after or during emergence.

between embryonic development, esterase activity and TEPP poisoning for eggs of *Pieris brassicae*, namely that in the poisoning process of the embryos inhibition of the cholinesterase is only a partial cause.

In the trial controls of mangold fly which were carried out in the field, we observed that leaf mining varied following application of the different products; this was not due solely to the differences in the initial effect. As Table 11 indicates, it was found on making a closer study that a big percentage of the larvae were already killed in the egg before emergence, by the organic phosphorus compounds.

Table 11:
Test No. 6 (Altwarmbüchen, Burgdorf).
Ovicidal effect of various products

Product	Dosage/ha	Total no. of killed larvae n[1])	Killed in leaf n[2])	Killed in leaf %	Killed in egg n[3])	Killed in egg %
DIPTEREX Emulsion	600 ccs	272	180	66	92	34
DIPTEREX Emulsion	900 ccs	287	241	84	46	16
DIPTEREX Soluble Powder	400 g	303	169	56	134	44
DIPTEREX Soluble Powder	600 g	306	195	64	111	36
Endrin Emulsion	600 ccs	260	247	95	13	5
Endrin Emulsion	400 ccs	289	279	97	10	3
Diazinon	600 ccs	265	175	66	90	34
E 605 conc.	300 ccs	149	72	48	77	52

n[1]) = Total no. of larvae killed in leaf and in egg in 25 sampled leaves
n[2]) = no. of larvae killed in leaf in 25 sampled leaves
n[3]) = no. of matured larvae killed in egg in 25 sampled leaves

This finding was made in Test No. 6 one week after the treatment so that all eggs laid before the spray application had hatched out. The spray application itself was carried out with the Mauser type high-pressure sprayer at a volume of 200 litres of spray solution per hectare and an operating pressure of 10 atmospheres gauge, in other words under practical conditions. Endrin emulsion and DIPTEREX soluble powder gave the following ovicidal effect in greenhouse tests:

Table 12:
Ovicidal effect in greenhouse tests

Product	Concentration %	Dead larvae in egg %	Dead larvae (no mines) %	Dead larvae (in mines) %
1. The plants were sprayed (also lower surface of leaves):				
DIPTEREX soluble powder [1])	0·05	80	20	0
Endrin emulsion [2])	0·1	36	24	40
2. The leaf surface was brush-coated:				
DIPTEREX soluble powder [1])	0·05	80	15	5
Endrin emulsion [2])	0·1	40	0	60

[1]) 50 % product [2]) 20 % product

In these tests, spraying was carried out 1 to 2 days after egglaying, and the check was made 6 days later at a time when the eggs in the untreated checks had hatched out. The results show that DIPTEREX soluble powder has an appreciable ovicidal effect also when the leaf surfaces are brush-coated, and according to Table 11 a good kill of larvae in the egg before they hatch out can be expected also in practical conditions. Mining and feeding by larvae in the leaves will be considerably reduced by an additional ovicidal effect of the preparations.

Fig. 5: Organic phosphorus compounds, in addition to having a good translaminar action, also produce an ovicidal effect against mangold fly, so that a large number of larvae are killed in the egg before they can hatch out (as shown here following a DIPTEREX treatment). The larvae, normally light-coloured and transparent, have already turned brown in the eggs, a sign that they are dead

A further possibility of checking feeding by mangold fly larvae is offered by treating seed with systemic insecticides, with the object of protecting young plants against early attacks by pests. Unterstenhöfer (1957b) reports that when seed was treated with DISYSTON®, control of mangold fly larvae was still given four weeks after the sugar beets had emerged. According to Steudel (1958), up to 100 % control of mangold fly larvae in young plants was given almost to the end of May following treatment of seed with systemic insecticides in Spring 1957. Steudel (1958) goes on to report that no further sprays were needed against the very abundant 1st. generation of mangold fly. It should be mentioned that sugar beet seed treatments with systemic insecticides are still in the experimental stage, and that they are primarily intended as a simplified

method for controlling virus-transmitting aphids in areas infected by virus yellows (Rhineland, Westphalia, Rheinpfalz). Since DISYSTON, apart from its aphicidal effect, also gives a good kill of mangold fly larvae, the seed treatment practice affords protection against several pests.

Question of yield decreases brought about by mangold fly attacks

The loss of foliage due to feeding by larvae is so considerable when there is an outbreak of severe infestation that yield losses are likely to be most appreciable if controls are not carried out. The plants perish or else their growth is greatly stunted. Precise studies conducted with the object of establishing the extent of damage caused are, therefore, of importance as an indicator to demonstrate the economy of controls.

Bremer (1929) dealt with this question in several tests and detailed studies of literature, and compared the loss of foliage and reduction of yields caused by larvae feeding on large plants with the yield depressions brought about by defoliating sugar beets for feeding purposes. Damage is very severe, however, when only a few leaves have formed on the plants at the time of attack. On the basis of studies conducted by the Institute for Sugar Beet Research in the Göttingen area, Winner (1958) reckons with yield losses of at least 10 %. Bremer (1929) recorded a yield decrease of 16 % in studies carried out in 1925 in Stralsund. To establish the extent of damage in the check plots, the laid eggs were removed regularly before hatching out. Jones and Dunning (1954), in controls carried out in 1949 with DDT, recorded beet yield increases of up to 11 % in comparison with untreated checks, despite the slow initial effect of the product and the limited mortality given. In 1956, Kersting (1957) carried out trial controls with parathion and diazinon in Westphalia; the beet yields harvested in the treated plots were more than 30 % greater than in the untreated checks. Koltermann (1958) conducted tests in 1956, in which he obtained yield increases, in comparison with the untreated checks, of 19 %, 23 % and 29 % for parathion, diazinon and DIPTEREX and endrin (both alike),

Table 13

Influence of mangold fly damage on the number of plants and the yield (according to Koltermann 1958)

	No. of plants per hectare[2])		Beet yield kilos/ha	%	Individual plant yield kilo	%
Treated (sprayed once)[1])	75,880	(100)	45,000	100	0·59	100
Untreated	65,600	(87)	38,400	85	0·59	100
Treated (sprayed twice)[1])	75,880	(100)	47,100	100	0·62	100
Untreated	65,600	(87)	38,400	82	0·59	95

[1]) Average for 6 tested products

[2]) These figures were kindly provided by Dr. Koltermann.

respectively. The leaf yields were also considerably bigger in the treated plots than in the untreated checks, a factor that is of no mean importance to the utilization of sugar beet tops as cattle feed. Exhaustive yield tests carried out by Koltermann (1958) in the Göttingen area during the severe infestation of 1957, produced very useful data on the causes of damage. The beet yield increases recorded in comparison with the untreated checks amounted to 13 % for parathion (sprayed once), 22 % for DIPTEREX (sprayed once), and 19 % for endrin (sprayed once). The number of plants per hectare was practically the same in the treated plots, and more than 10 % less in the untreated plots, as shown by the average figures listed in Table 13.

It is evident from these figures that a large number of plants died in the untreated plots as a result of the severe infestation so that the appreciably lower yields per unit of area in the untreated plots might easily be attributed to the smaller crop density if the calculated yield per individual plant were not to give rise to other considerations.

According to the studies on the relationships between the number of plants per hectare, the individual plant yield and the yield per unit of area, an increase in the yield of the individual plant is to be expected as the number of plants per hectare decreases, this being due to the fact that each plant then has a greater space to itself, with the result that the yield per unit of area is counterbalanced to a certain extent. The following relationships were established by Klapp (1949) in several years of studies on spacing between sugar beet plants.

Table 14

Relationships between number of plants per hectare, individual plant yield and yield per hectare (according to Klapp 1949)

Test year	No. of plants per hectare		Beet yield kilos/ha	%	Individual plant yield kilo	%
1939	76,700	(100)	44,960	100	0·59	100
	57,100	(74)	48,400	108	0·85	144
1940	84,000	(100)	38,470	100	0·46	100
	62,500	(74)	41,840	109	0·67	146
1941	78,400	(100)	45,000	100	0·57	100
	52,800	(67)	43,500	97	0·82	144
1942	81,060	(100)	37,280	100	0·46	100
	70,120	(81)	39,980	107	0·57	124

The appreciable differences in crop density were offset in these studies by the greater yield for each individual plant so that for the lower number of plants per hectare bigger yields per unit of area were obtained in certain cases. Hinckers (1927) established similar relationships as shown in Table 15.

Table 15

Relationships between no. of plants per hectare, individual plant yield and yield per hectare (according to Hinckers 1927)

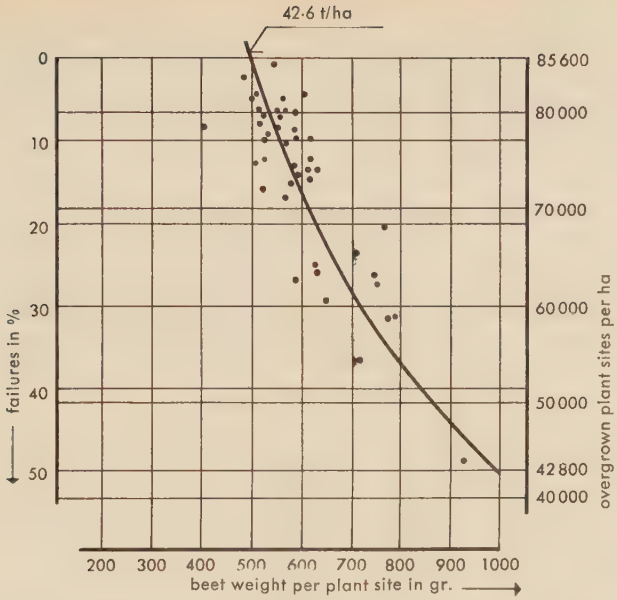
	No. of plants per hectare		Beet yield kilos/ha	%	Individual plant yield kilo	%
Early harvest	91,500	(100)	35,700	100	0·40	100
	56,250	(62)	33,800	95	0·61	153
Late harvest	91,500	(100)	37,300	100	0·41	100
	56,250	(62)	36,000	97	0·65	159

Even though the crop density is decreased here by 38 %, the difference in the yield per unit of area is very limited due to the higher yield for each individual plant. Riedel (1956) who gave close attention to effects of mechanical hoeing and thinning on the resultant large number of failures, within the scope of an extensive study on spacing as a mechanization problem of beet cultivation, arrived at the conclusion based on the results he obtained that a balance of yield, even though not complete, is brought about due to the higher yield per individual plant to give a crop density, which is well below the usual. As shown in Graph 9, the individual plant yields recorded in the tests conducted by Riedel (1956), for all checked crop densities or percentages of failures are closely spread around a curve which corresponds to the average yield of 42,600 kilos per hectare.

The object of giving these test results was to show that in normal conditions the calculated individual plant yield (Table 13 — according to studies of Koltermann 1958) in untreated plots or with a low number of plants per hectare, would have been considerably bigger and have led to a yield balance. The appreciable yield depression in the severely infested, untreated plots is, therefore, not to be attributed especially to the lower crop density but mainly — as the preceding facts were intended to show — to the stunting of growth among the individual plants caused by mangold fly attacks.

The established relationships were plotted with the prime object of showing indirectly that the mangold fly — when it occurs on a large scale — not only kills numerous young plants but also essentially harms the individual plant affecting its development. Control of mangold fly aiming at checking feeding by larvae is, therefore, not a "beauty treatment" (to prevent the leaves from dying) but is necessary in order to eliminate serious stunting of the growth of individual plants.

These views also show that recommendations regarding a closer crop within the scope of yellows control are of general importance to the prevention of pest infestation in beet fields. Moreover, stunting of the growth of individual plants in dense crops does not have the effect of reducing the yield so greatly as when crops are well spaced out due to failures. Therefore, in addition to direct controls of plant diseases and insect pests, cultivation practices are also important.



Graph 9: Relationships between no. of plants per unit of area, individual plant yield and yield per unit of area (according to Riedel 1956)

Summary

The mangold fly, known for some considerable time past as an epidemic pest occurring on beet crops, has again caused appreciable damage during recent years in several countries of Europe. The injuries inflicted by the mangold fly are brought about primarily by larvae of the spring generation (1st. generation) mining and feeding in the parenchyma of the leaf, with the result that the growth of beet plants, especially when they have only formed a few pairs of leaves, is stunted; when infestation is severe, the attacked plants die. In order to prevent the resultant yield decreases, it is essential to control the mining larvae or to kill these larvae before they hatch out.

In earlier times, farmers were helpless against mangold fly infestation — as we have noted from the references quoted — but today an effective and rapid kill of larvae (prior to and after emergence) is given with the aid of modern insecticides, thus eliminating serious yield losses.

Extensive trial controls of mangold fly larvae were carried out from May 14 to June 15, 1957 in the severely infested districts of the Hanover-Hildesheim-Göttingen area. The initial action and residual effect were tested for several DIPTEREX formulations in comparison with other products, applied at various volumes by aircraft and ground sprayers. Another object of these tests was to establish what dosages of DIPTEREX must be added to the dosage of METASYSTOX (i) applied against aphids, in order also to produce a rapid and

adequate effect against mangold flies, when these two products are combined to give simultaneous control of mangold flies and aphids. A study was also made to find out whether DIPTEREX and other products also produce an ovicidal effect in addition to the larvicidal effect, in other words whether the spray kills the embryos in the eggs before the larvae can hatch out, in addition to controlling larvae mining in the leaves. The following conclusions are drawn from the results obtained in these tests:

1. The initial action and the residual effect given by the products tested are practically the same at various volumes, and also when applied by ground sprayers and aircraft. A point of importance with respect to aircraft applications is that an evenly distributed spray mist must be produced, especially in view of the low volume applied amounting to 40 litres per hectare. Certain difficulties are generally experienced in the treatment of beets grown for seed production because the vigorous rosette growth prevents uniform atomizing of the leaves.

2. The residual effect given by the different products and active ingredients was overrated in last year's investigations. The severe infestation that commenced as the beets emerged, the persistent oviposition and the great increase of new foliage during the early growth of the plants, enabled the minimum residual effect of the test products to be established in the infestation conditions of 1957. The residual effects determined for the listed products were as follows:

E 605 conc.	(210—300 ccs/ha)	4 to 5 days
Diazinon	(600 ccs/ha)	5 to 7 days
DIPTEREX Emulsion *)	(600 ccs/ha)	10 to 12 days
DIPTEREX Wettable Powder *)	(600 g/ha)	10 to 12 days
DIPTEREX Soluble Powder **)	(400 g/ha)	10 to 12 days
DIPTEREX Soluble Powder *)	(600 g/ha)	10 to 12 days
Endrin Emulsion	(400 ccs/ha)	10 to 13 days

   An increase of the dosages did not bring about any appreciable improvement of the initial action and the residual effect.

3. Whereas diazinon, DIPTEREX and E 605 conc. have a good initial action, and give a 100 % kill of larvae after 24 hours (and earlier), the initial action of endrin is slower. This latter product does not give a 100 % kill until after 48 (to 72) hours although under certain circumstances it may be observed to check the feeding activities of the larvae. In order to offset the slow initial action of endrin, spraying contractors frequently apply endrin in combination with diazinon, DIPTEREX or E 605 conc.

4. Diazinon, DIPTEREX and E 605 — all organic phosphorus compounds — have a good ovicidal effect against mangold flies, in other words some of the larvae are killed in the egg before they can hatch out. As a result of this, the overall spray effect is increased by no small means.

5. In the event of mangold flies and aphids occurring simultaneously, an effective kill of mangold fly larvae is given by adding DIPTEREX wettable powder *) or DIPTEREX soluble powder *) (300 g ha) or, alternatively, DIPTEREX emulsion *) (300 ccs/ha) to the dosage of METASYSTOX (i)

*) active ingredient content of 50 %
**) active ingredient content of 80 %

usually applied against aphids. This problem is of importance especially in areas where constant damage is inflicted by outbreaks of yellows.

Concerning the question of yield losses brought about by mangold fly infestation, it was established from the data obtained that the decrease in yield is not so much due to the reduction of the crop density caused by severe infestation, but is to be attributed primarily to the growth depression of the remaining crop caused by mining and feeding. Normally when there is a reduced crop density, the yield per unit of area is counterbalanced by the greater yields obtained for each individual plant but when mangold fly infestation is severe the growth of the individual plant, especially in the early stage, is too greatly stunted for a balance of yield to be realized. Since the numerous studies conducted have shown that the decreases in yield caused by moderate to severe infestation amount to at least 10 %, controls of mangold fly larvae are of great economic importance.

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Importance of rain-resistant property of fungicides to the control of *Phytophthora infestans* de Bary

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The general opinion is maintained that *Phytophthora infestans* occurs on potato crops only in certain meteorological conditions, and of course also when the biological conditions are favourable to incidence. Although authors (Beaumont 1947, Bochow 1954/55, Bourke 1953, Hänni 1949, Harrison 1947, Hyre 1952, Johannes 1953, Müller and Griesinger 1942,

Orth 1937, Thran 1952, Uhlig 1955/56, Walling and Waggouer 1949, Wallin, Wade and Darling 1953) differ in their views on the actual temperatures and relative humidity that must prevail, and as to how long the leaves must be wet for infections to be caused, they are all unanimous in stating that relative humidity must be high and that liquid water must be present in droplets on the leaves (Ullrich, 1957).

During the critical season for outbreaks of *Phytophthora,* periods of frequent rainfall are, therefore, especially hazardous. Moreover, rain attacks the coating of fungicidal active ingredients applied to plants in preventive treatments. In view of this, the obvious step was to increase the efficacy of treatments by improving the rain-resistant property of products suitable for controlling *Phytophthora,* and to reduce the number of applications needed. In order to clarify the question whether an improvement of the rain-resistant property would actually lead to a better biological effect, it appeared worthwhile to carry out comparison tests with products which as far as possible differed only in their rain-resistant properties. Farbenfabriken Bayer A. G., Leverkusen, readily complied with my request for supplies of suitable test products to conduct these studies, and I should like to express my thanks to this company for its cooperation.

I. Rain-resistant property of products

The differences in the rain-resistant property of the products tested which will be referred to as A, B and C in this paper, were established in laboratory and field trials. At the laboratory of Farbenfabriken Bayer A. G., glass plates sprayed with the products were immersed in water, and the degree of adhesion (resistance to washing off) was determined. After subjecting the sprayed glass plates to a rain-exposure-test (5 mm/5 mins.), the degree of resistance to rain was established. The result of this test is given in Table 1.

Table 1: Results of rain-resistance test in laboratory

Product	Resistance to washing-off and rain-resistance	
	Residual quantity of copper after immersion of glass plate expressed in %	Residual quantity of copper after rain-exposure-test expressed in %
A	81	66
B	62	19
C	54	16

Since it could not be predicted with certainty that the products would react in the potato field in the same way as in the laboratory, determinations of active ingredient were carried out according to the method of colorimetric determination devised by Neuhaus (1952), which is described in the paper published by Goossen and Eue (1955). These studies — altogether about

10,000 colorimetric determinations of copper were carried out on potato pinnae before and after rainfall — gave the rain-resistance values listed in Table 2 for the different preparations. The values for the rain-resistance of the products determined in the potato field correspond gradually to the laboratory results although the differences in rain-resistance between product A, on the one hand, and products B and C (less resistant to rain in the laboratory), on the other hand, are not so large. In fact, the degree of rain-resistance shown by the products in the potato field was altogether surprising. After rainfall of 21·2 mm only 27 to 33 % of the active ingredient was washed off the leaves; following a total of 102·6 mm rainfall, 76 to 80 % of the copper oxychloride was washed off.

Table 2: Results of rain-exposure-test in the field

Product	Quantity of copper expressed in % (before rainfall = 100 %)		
	before rainfall	after 21·2 mm rainfall	after 102·6 mm rainfall
A	100	73	24
B	100	69	21
C	100	67	20

II. Trial controls of *Phytophthora*

The object of the trial controls of *Phytophthora* carried out with the above-mentioned products in 1954 and 1955 was to establish differences in the fungicidal action of these products in dependence on amounts of rainfall. The products were applied by spraying and atomizing them at varying volumes (200, 400 and 600 litres per hectare). The quantity of copper oxychloride used in all the tests was regulated so that a dosage of copper amounting to 2250 gr. was applied per hectare. The evaluation included 2 and 3 checks on foliage according to the following rating:

0 = no infection
1 = symptoms of initial infection on isolated leaves
2 = numerous spots, isolated leaves already destroyed
3 = severe symptoms of infection, isolated shoots already perished
4 = severe damage to whole of potato foliage
5 = plant completely destroyed

In the test carried out in 1954 on the "Bona" variety (Table 3), the best control was found to have been given by product A — the preparation most resistant to rain — at the time of the 1st. check, whereas at the 2nd. check this product was in its efficacy well behind product C which featured the weakest resistance to rain. Product B held second place throughout the whole of the testing period. 66·7 mm of rain fell between the 1st. and 2nd. checks.

Table 3: Results of leaf checks

Test No.	Product	Dosage of copper in gr.	Volume in litres per hectare	Method of application	Leaf checks on 19. 8. 1954						Leaf checks on 2. 9. 1954					
					0	1	2	3	4	5	0	1	2	3	4	5
1	untreated	—	—	—	0	0	0	73	27	0	0	0	0	0	100	0
2	A	2250	600	spraying	0	0	54	45	1	0	0	0	0	25	73	2
3	B	2250	600	spraying	0	0	42	55	3	0	0	0	0	35	63	2
4	C	2250	600	spraying	0	0	26	71	3	0	0	0	0	54	46	0

1st. spray on July 9, 1954 — 2nd. spray on August 2, 1954

A test carried out in 1955 in which crops of the "Vera" variety were atomized at a rate of 400 litres per hectare (Table 4) again found product A with the best effect at the 1st. check but as before products B and C headed the results at the 2nd. check. The rainfall recorded during the testing periods was as follows:

18·8 mm from July 12 to August 1, 1955
34·8 mm from August 1 to August 10, 1955

Table 4: Results of leaf checks

Test No.	Product	Dosage of copper in gr.	Volume in litres per hectare	Method of application	Leaf checks on 1. 8. 1954						Leaf checks on 10. 8. 1954					
					0	1	2	3	4	5	0	1	2	3	4	5
1	untreated	—	—	—	0	0	2	34	40	24	0	2	0	0	28	70
2	A	2250	400	atomizing	0	12	36	24	22	6	0	0	0	18	32	50
3	B	2250	400	atomizing	0	16	30	24	18	12	0	0	0	20	40	40
4	C	2250	400	atomizing	0	0	68	29	3	0	0	0	10	38	44	8

1st. spray on July 12, 1955 — 2nd. spray on August 1, 1955

In a third test in which crops of the "Ackersegen" variety were sprayed (Table 5), the products B and C were found to be superior to product A at the 1st. and 2nd. checks. 39·8 mm of rain fell between the 1st. spray application and the 1st. check, while 19·3 mm of rainfall was recorded in the period between the 1st. and 2nd. checks.

At the time the 1st. check was made in the 1955 test spraying of the "Ackersegen" variety at a volume of 200 litres per hectare (Table 6), there were still no differences in the state of the foliage between the untreated and treated plots. At the 2nd. check, however, the foliage in the treated plots was appre-

ciably healthier than in the untreated plots, although only relatively little difference in effect was registered for the three test products.

It was merely in the spray test (600 litres per hectare) carried out on crops of the "Vera" variety that product A was found to have a clear advantage over

Table 5: Results of leaf checks

Test No.	Product	Dosage of copper in gr.	Volume in litres per hectare	Method of application	Leaf checks											
					on 15. 8. 1955						on 25. 8. 1955					
					0	1	2	3	4	5	0	1	2	3	4	5
1	untreated	—	—	—	0	74	24	2	0	0	0	58	20	20	2	0
2	A	2250	400	spraying	0	76	20	4	0	0	0	60	20	18	2	0
3	B	2250	400	spraying	2	86	12	0	0	0	0	70	20	10	0	0
4	C	2250	400	spraying	0	80	20	0	0	0	0	78	16	6	0	0

1st. spray on August 4, 1955 2nd. spray on August 16, 1955

Table 6: Results of leaf checks

Test No.	Product	Dosage of copper in gr.	Volume in litres per hectare	Method of application	Leaf checks											
					on 10. 8. 1955						on 25. 8. 1955					
					0	1	2	3	4	5	0	1	2	3	4	5
1	untreated	-	-	—	0	76	24	0	0	0	0	58	20	20	2	0
2	A	2250	200	spraying	0	74	26	0	0	0	0	88	8	4	0	0
3	B	2250	200	spraying	0	76	24	0	0	0	0	80	14	6	0	0
4	C	2250	200	spraying	0	76	20	4	0	0	4	80	10	6	0	0

1st. spray on August 4, 1955 2nd. spray on August 16, 1955

Table 7: Results of leaf checks

Test no.	Product	Dosage of copper in gr.	Volume in litres per hectare	Method of application	Leaf checks																	
					on 1. 8. 1955						on 5. 8. 1955						on 10. 8. 1955					
					0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3	4	5
1	untreated	—	—	-	0	0	2	34	40	24	0	0	0	9	37	54	0	2	0	0	28	70
2	A	2250	600	spraying	0	74	18	2	2	4	0	50	36	12	2	0	0	6	16	44	32	2
3	B	2250	600	spraying	0	40	32	6	10	12	0	30	64	6	0	0	0	0	0	34	50	10
4	C	2250	600	spraying	0	0	38	32	14	16	0	0	20	30	22	28	0	0	4	16	50	30

1st. spray on July 12, 1955 2nd. spray on August 1, 1955

the other preparations throughout the whole of the testing period. The rainfall recorded during this testing period was as follows:

18·8 mm from July 12 to August 1, 1955
8·1 mm from August 1 to August 5, 1955
26·7 mm from August 5 to August 10, 1955

III. Discussion of results

When a good rain-resistant property of a product is of advantage to the control of *Phytophthora*, then the product featuring the greater resistance to rain should give a better effect. In particular, it should be superior to products less resistant to rain during periods of heavy rainfall. Therefore, in 1954 when the average rainfall was 2·9 mm per test day, and 4·8 mm between the 1st. and 2nd. checks, product A ought to have been superior to products B and C. But it was only in one out of four evaluated tests (the spray test carried out at a rate of 200 litres per hectare did not give any significant differences) that product A was superior, and this most surprisingly in a test where the average daily rainfall during the testing period amounted to only 1·8 mm. The author is fully aware that the test results compiled in this paper are not adequate to give a final answer to the question as to the correct degree of rain-resistance of fungicides suitable for controlling *Phytophthora*. These results do, however, indicate, as Goossen and Eue (1956) suggested, that the absolute rain-resistance of a fungicide must result in a decrease of effect in the control of *Phytophthora*. These authors arrived at this conclusion in their studies because they maintain that with the conventional methods of application and crop protection equipment, such technical requirements as an especially thorough treatment of the bottom third of the plant and the lower surfaces of the leaves, can by no means be fully satisfied. It is not until rain falls that the active ingredient is transported to those parts of the plant particularly exposed to infection. Rain carries the active ingredient

a) from the top section of the plant to the bottom parts
b) from the upper surface to the lower surface of the leaf (Fig. 1), and
c) from the base of the pinnate leaf to the edge and tip of the leaf, usually on the upper surface.

Active ingredient can, however, only be transported by rain or dew to endangered parts of the plant, as long as the copper reserve is not exhausted. This copper reserve is the relatively large quantity deposited in the top third of the potato plant. If it is necessary for the active ingredient to be carried by rain in order to transport the fungicide to the parts exposed to infection, then the product must to a certain degree be "susceptible to rain". According to the results given in this paper, it is advisable to improve the rain-resistant property of fungicides only up to a certain degree. It is obvious that this critical limit is already exceeded for product A. Maximum rain-resistance must not necessarily, as is often done, be placed on a par with the best effect. In my opinion, the degree of rain-resistance is already fully adequate for a number of conventional preparations particularly as the growth of new foliage on plants may be so considerable at the time when spray applications have to be carried out against *Phytophthora* that the leaf area is trebled within 14 days (Goossen and Eue

1956), thus making it necessary to repeat the treatment at intervals of 10 to 14 days in periods critical for outbreaks of *Phytophthora*, even when the products feature excellent rain-resistant properties.

The positive results obtained in a control of *Phytophthora* carried out with an aeroplane (J ä g e r 1957) at a volume of only 40 to 60 litres per hectare, support the theory that it is necessary for the active ingredient to be transported by rain to the lower parts of the plants. Using droplets of more than 150 microns and such low volumes as are necessary for aircraft applications, it is not possible to give the potato plants full coverage. In such cases, and also in

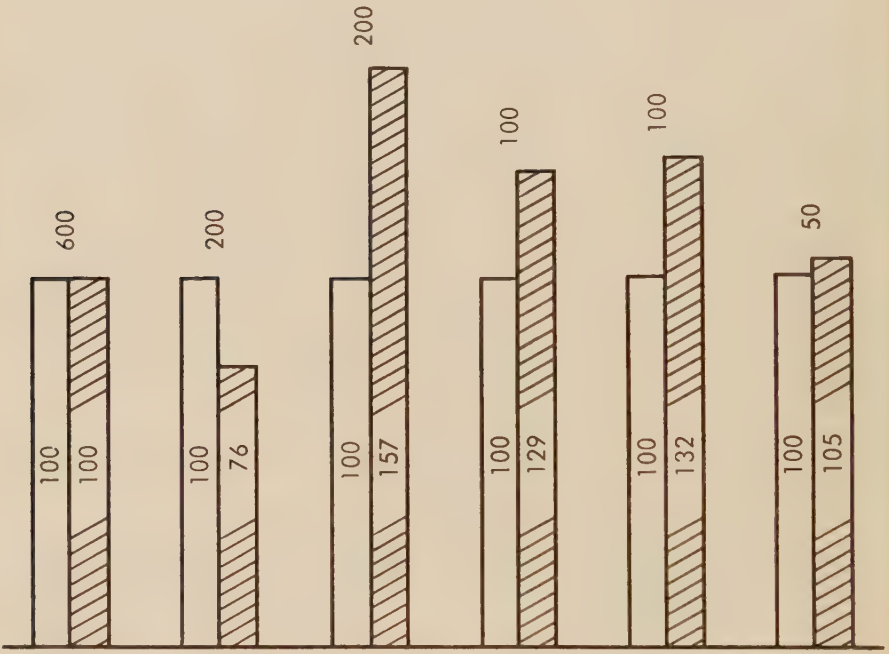

Fig. 1: Relative quantities of active ingredient in percentage on the lower surface of the leaves. Values before rainfall (100 %) white, after rainfall shaded. Spraying at olumes of 600 and 200 litres per hectare, atomizing at volumes of 200, 100, 100 and 50 litres per hectare.

others, the effect produced is undoubtedly governed by the quantity of active ingredient actually deposited on the crop. The active ingredient is then distributed and transported by dew and rain — important to the outbreak of infection — in the case of those products somewhat "susceptible to rain".

The data obtained as secondary results in the above-mentioned colorimetric determinations of copper, regarding the deposit of active ingredient on the crop when using sprayers with volumes of 200, 400, 600 and 800 litres of spray solution per hectare, also indicate the decrease in effect at too high or low

volumes (Aebi, Trivelli, Staehelin 1956; Blunck 1949; Schumacher 1950, 1953; Goossen 1952; Johannes 1952; Dame 1953; Thiede 1956), based simply on the fact that both at high (800 litres per hectare) and at low volumes (200 litres per hectare) losses of active ingredient are brought about due to dripping or drift, which in value are to be rated much higher (Fig. 2) than the effect that can be given by a further improvement of the rain-resistance property of commercial products. When absolutely less active ingredient is deposited on the crop, the reserve of active ingredient in the top parts of the plant will automatically be exhausted earlier due to the necessity of active ingredient being transported to the lower plant parts. In

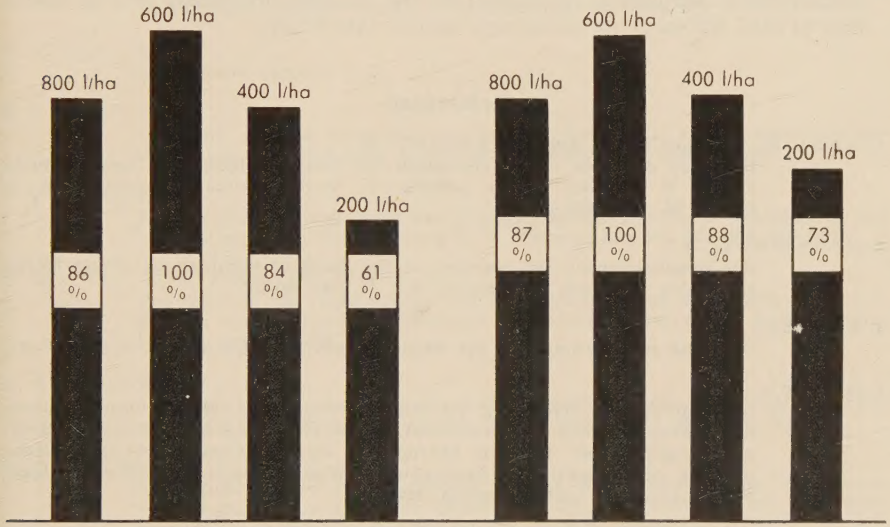

Fig. 2: Deposit of active ingredient on crop for volumes of 800, 600, 400 and 200 litres per hectare. The fact that losses of active ingredient are not due to the machines used is obvious when it is considered that in two test series the conditions are similar (a and b) even though different machines were used.

control operations carried out with helicopters and aircraft, an adequately large quantity of fungicide will be deposited despite the low volume, because utilization of the slipstream or downblast of the rotor makes for the deposit of small droplets, too.

IV. Summary of the most important results

1. Rain-resistance studies carried out in the laboratory do not alone give a definite indication of the rain-resistance property of a product on plants in the field.
2. Copper oxychloride preparations featuring good resistance-to-rain properties did not give better control of *Phytophthora* than preparations less resistant to rain.

3. The rain-resistance of fungicides effective against *Phytophthora* should not be increased above a certain degree because transport of active ingredient by rain and dew to low parts of the plants constitutes a condition essential to the success of a control operation.

4. To obtain good efficacy in controls of late blight, it is important that as much as possible of the quantity of active ingredient applied is deposited on the crops. Even distribution, on the other hand, does not attach such great importance as one has previously assumed.

5. The relationships existing between rainfall and *Phytophthora* infection, and transport of the active ingredient by rain should lead to farmers utilizing at all costs a period of poor weather with intermittent, slight falls of rain and temperatures favourable to spread of the disease prevailing during hours free of rain, for carrying out sprays against late blight.

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